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DETERMINATION OF SLAUGHTER-STEER GRADES FROM WEIGHTS AND MEASUREMENTS

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INTRODUCTION

In the study of data on steers, a rather close association was found between height at withers and weight, on the one hand, and slaughter grade on the other. Knapp and Cook[2] showed that there were breed differences in ratio of weight to height at withers and suggested the use of this ratio as a measure of beef type. Brody and Ragsdale[3] presented a method of determining condition in dairy cattle by the use of height at withers and weight. The method discussed in this circular closely parallels that of Brody and Ragsdale. Black, Knapp, and Cook[4] found that, in a weight-constant population, height at withers was closely associated with slaughter grade.

Lush,[5] in a study of measurements of steers during intensive fattening, found a correlation of 0.563 between a ratio of heart girth to height at withers and estimated fatness. He stated[6] that large flesh measurements but small bone measurements are indications of a fat, heavily muscled steer.

In view of these findings, it seemed advisable to devise a method of determining the slaughter grades of steers for use by the experiment station worker, the extension man, or the cattle feeder who may be faced with the problem of grading a group of steers on feed but who cannot obtain the services of technically trained cattle graders. The method must be such that it can be quickly applied and yet be accurate enough for practical use in the field. To fill this need, the methods reported in this circular were worked out. One involves the determination of grades from height at withers and weight. Since scales sometimes are not available, a method is given also for determining grades from height at withers and heart girth.

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[1] Acknowledgment is made to J. R. Douglas, J. M. Jones, F. E. Keating, and A. C. Cook, of the Bureau of Animal Industry, for some of the measurements on the cattle; and to L. B. Burk and M. T. Foster, of the Bureau of Agricultural Economics, and A. C. Cook, R. L. Hiner, W. H. Black, and J. M. Jones, of the Bureau of Animal Industry, for grading the steers used in this study.

[2] Knapp, Bradford, Jr., and Cook, A. C. A COMPARISON OF BODY MEASUREMENTS OF BEEF AND DUAL-PURPOSE CATTLE. Amer. Soc. Anim. Prod. Proc. (1932) 25: 77-84, illus. 1933.

[3] Brody, S., and Ragsdale, A. C. ESTIMATING CONDITION IN DAIRY CATTLE. Mo. Agr. Expt. Sta. Bull. 355, 11 pp., illus. 1935.

[4] Black, W. H., Knapp, Bradford, Jr., and Cook, A. C. CORRELATION OF BODY MEASUREMENTS OF SLAUGHTER STEERS WITH RATE AND EFFICIENCY OF GAIN AND WITH CERTAIN CARCASS CHARACTERISTICS. Jour. Agr. Research 56: 465-472, illus. 1938.

[5] Lush, J. L. CHANGES IN BODY MEASUREMENTS OF STEERS DURING INTENSIVE FATTENING. Tex. Agr. Expt. Sta. Bull. 385, 59 pp., illus. 1928.

[6] ——— THE RELATION OF BODY SHAPE OF FEEDER STEERS TO RATE OF GAIN, TO DRESSING PER CENT, AND TO VALUE OF DRESSED CARCASS. Tex. Agr. Expt. Sta. Bull. 471, 30 pp., illus. 1932.

MATERIALS AND METHODS

The data used in this study were the weights, measurements, and grades of 167 slaughter steers. Every effort was made to obtain a fair sample of commercial cattle so that the data would be reasonably applicable to any cattle regardless of location, breed, or condition of fleshing. The steers used included both purebred and grade animals and were of the following breeding and numbers: Hereford, 79; Shorthorn, 69; Aberdeen Angus, 13; and steers of dairy breeding, 6. The ages of most of the animals were from about 1 to 2 years. All steers had been fed at least 120 days on various feeds in several experiments; a few had been fed as long as 300 days. The weights of the slaughter steers ranged from about 600 to 1,400 pounds. The weights were usually an average of those taken on 3 successive days, but a few 1-day weights were used. The slaughter grades ranged as follows: Prime, 9 steers; Choice, 45; Good, 64; Medium, 43; and Plain (formerly designated as Common), 6. The grades used were those officially adopted by the Bureaus of Agricultural Economics and Animal Industry, United States Department of Agriculture, and represented, in the case of the animals used, the average grades given by a committee of two or three technically trained cattle graders.

Height at withers is used more frequently than length of body as an index of skeletal size because it can be measured more accurately. The former measurement in mature animals is unaffected by changes in weight and is practically independent of environmental conditions. Because of this fact, it is one of the best expressions of the hereditary size of the animal. Height at withers, unlike weight and linear measurements closely associated with weight, is largely acquired prior to birth. In cattle, about 50 percent of the mature height at withers is completed before birth, whereas only about 4 percent of the mature weight is attained at that time. Maturity in skeletal growth therefore is reached at a much earlier age than is weight. Because there are different rates of increase and different ages of maturity for height at withers and weight, there should be a curvilinear relationship between these two factors during growth. Since, in slaughter animals, maturity of both height at withers and weight is seldom reached, the relationship between the two must remain curvilinear. It has been shown by Brody and Ragsdale[7] that changes in condition of fleshing have little or no effect on height at withers. Therefore, during any period of growth from birth to maturity, changes in thickness of fleshing will change the ratio of weight to height at withers. The steer that weighs the most for a certain skeletal size must have the thickest flesh provided the amount of fill is about the same.

For the proper measurement of height at withers, the steer should stand squarely on his four feet on a level floor with his head in a normal upright position, and the measurement should be taken on the top line at the center of the scapulas (shoulder blades). In the present study height at withers was taken in centimeters with a measuring rod (fig. 1). This rod may be constructed from metal or hardwood. A small level on the arm of the rod shows when the rod is perpendic-

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[7] BRODY, S., and RAGSDALE, A. C. See footnote 3.

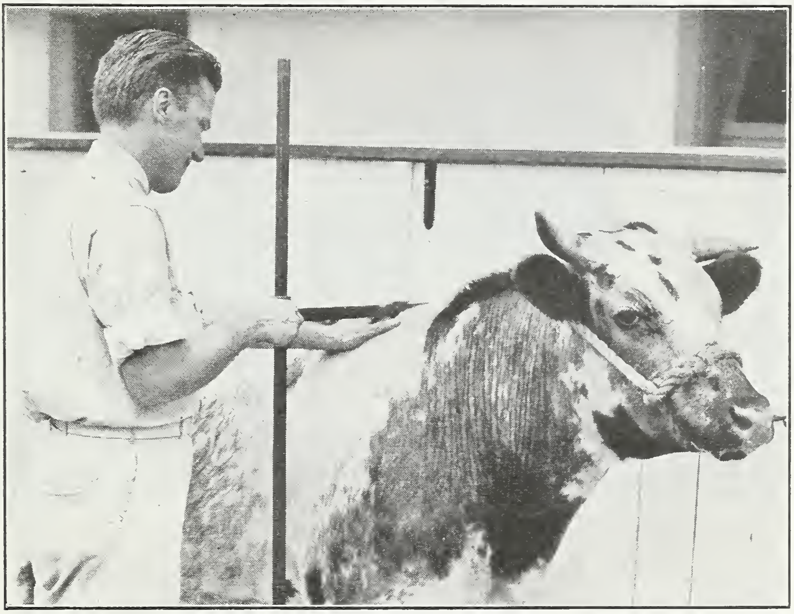

FIGURE 1.—Taking height at withers with measuring rod. The horizontal arm contains a small level.

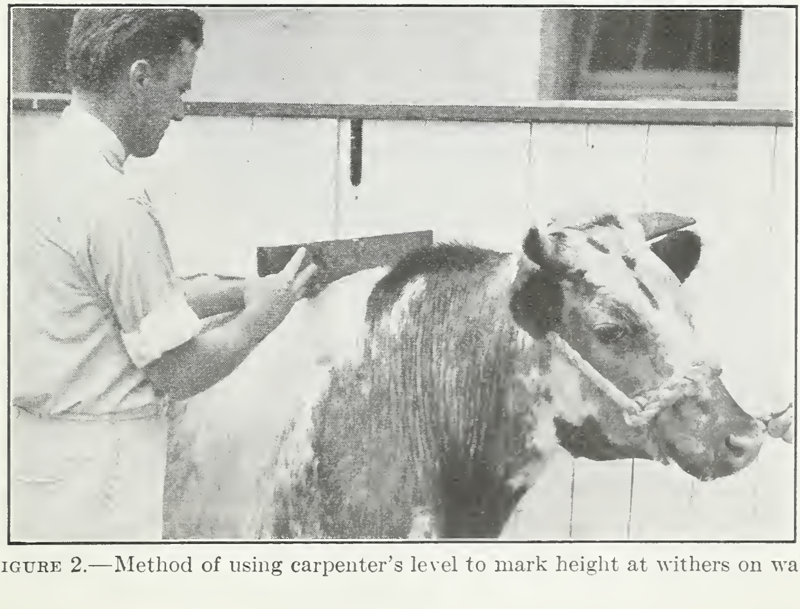

FIGURE 2.—Method of using carpenter's level to mark height at withers on wall.

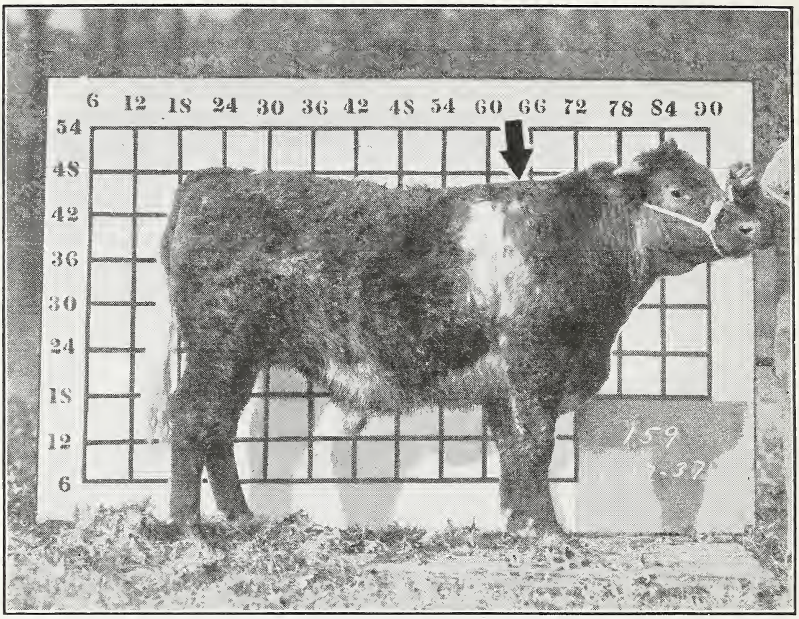

FIGURE 3.—Taking height at withers against a ruled background. Arrow indicates point of measurement. This steer stood 47 inches high at the withers.

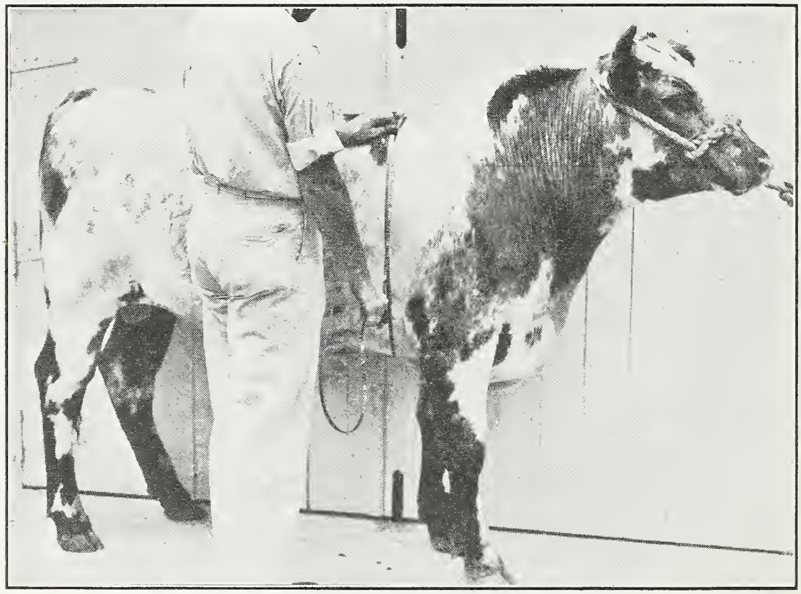

FIGURE 4.—Obtaining heart-girth measurement of an animal.

ular. However, there are several satisfactory methods for taking this measurement. In figure 2 a simple method is shown—that of using the side of a building or high board fence and a carpenter's level, marking the proper height, and measuring from that point to the ground. A carpenter's square may be substituted for the level. Another method is to obtain the height at withers against a ruled background (fig. 3).

Heart-girth measurements were obtained by the method shown in figure 4.

DETERMINATION OF SLAUGHTER GRADES

Since two measures, height at withers and weight, and the relationship between any change in them and the change in a third factor, slaughter grade, are involved, a multiple regression equation was used to fit the data. As stated previously, a curvilinear relationship should exist between weight and height at withers. Therefore, a multiple curvilinear regression should express the true relationship among the three factors. The data were fitted to curves according to the methods of Ezekiel [8] and expressed by the formula

$$Y = a + b_{12}(X_2) + b_{13}(\log X_3)$$

The values for the equation derived from the slaughter-grade data were

$$\text{Grade} = -223.2839 - 3.5853\ (H) + 157.9825\ (\log W),$$

in which grade is the slaughter grade in percent, (H) is the height at withers in inches, and $(\log W)$ is the log of live weight in pounds.

Table 1 was calculated by transposing this equation to

$$\text{Log } W = \frac{223.2839 + 3.5853\ (H) + \text{Grade}}{157.9825}$$

This table shows the slaughter grades of animals determined from the indicated heights at withers and the ranges in weight for each full grade. If it is desired to determine thirds of a grade, the equation previously given for determining grade may be used. The omission of weights at the end of each column giving the higher grades is explained by the fact that, as an animal acquires an excess of skeletal size, it becomes increasingly difficult for it to attain the degree of fatness required in the higher grades. For example, a steer whose height at withers is 55 inches may grade Prime if he carries an excessive amount of weight, but he is more likely to grade only Choice or below.

To test the accuracy of this method, both the judged and the determined grades were obtained on 28 individual steers (table 2). The former grades were obtained by two technically trained graders, and the latter by measurements. The greatest deviation between the judged and determined grades was one-half of a grade in steer No. 4. However, the writer has found that an error of one-fourth to one-third of a grade occurs when a committee of three men grade a group of steers. This error, together with the random error in measurement of height at withers and in obtaining weight, probably accounts for most of the error in the present method. Black, Knapp, and Cook,[9] showed that when the ratio of weight to height at withers was correlated with percentage of edible portion in the carcass, the judged slaughter grade did not give a significantly higher correlation than slaughter grade determined by this method, the difference being 0.0657 ± 0.0742.

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[8] EZEKIEL, MORDECAI. METHODS OF CORRELATION ANALYSIS. 427 pp., illus. New York. 1930.

TABLE 1.—*Slaughter-grade classification of steers on the basis of height at withers and weight*

Height of steers at withers (inches)	Weight of steers that grade—				
	Prime	Choice	Good	Medium	Plain
	Pounds [1]	*Pounds*	*Pounds*	*Pounds*	*Pounds* [2]
38	701	606– 700	523– 605	452– 522	451
38½	719	622– 718	537– 621	464– 536	463
39	738	638– 737	552– 637	477– 551	476
39½	758	655– 757	566– 654	489– 565	488
40	778	672– 777	581– 671	502– 580	501
40½	798	690– 797	596– 689	516– 595	515
41	820	708– 819	612– 707	529– 611	528
41½	841	727– 840	628– 726	543– 627	542
42	863	746– 862	645– 745	558– 644	557
42½	886	766– 885	662– 765	572– 661	571
43	910	786– 909	680– 785	588– 679	587
43½	934	807– 933	698– 806	603– 697	602
44	959	829– 958	716– 828	619– 715	618
44½	984	851– 983	735– 850	635– 734	634
45	1, 010	873–1, 009	755– 872	652– 754	651
45½	1, 037	896–1, 036	775– 895	670– 774	669
46	1, 064	920–1, 063	795– 919	688– 794	687
46½	1, 092	944–1, 091	816– 943	706– 815	705
47	1, 121	969–1, 120	838– 968	724– 837	723
47½	1, 151	995–1, 150	860– 994	743– 859	742
48	1, 181	1, 021–1, 180	883–1, 020	763– 882	762
48½	1, 213	1, 047–1, 212	906–1, 046	783– 905	782
49	1, 245	1, 074–1, 244	930–1, 073	804– 929	803
49½	1, 278	1, 104–1, 277	955–1, 103	825– 954	824
50	1, 312	1, 134–1, 311	980–1, 133	847– 979	846
50½	1, 346	1, 164–1, 345	1, 006–1, 163	869–1, 005	868
51	1, 382	1, 195–1, 381	1, 033–1, 194	892–1, 032	891
51½	1, 419	1, 226–1, 418	1, 060–1. 225	916–1, 059	915
52	1, 456	1, 259–1, 455	1, 088–1, 258	940–1, 087	939
52½	(3)	1, 292 or more	1, 117–1, 291	965–1, 116	964
53		1, 326 or more	1, 146–1, 325	991–1, 145	990
53½		1, 361 or more	1, 177–1, 360	1, 017–1, 176	1, 016
54		1, 397 or more	1, 208–1, 396	1, 044–1, 207	1, 043
54½		1, 434 or more	1, 240–1, 433	1, 072–1, 239	1, 071
55		1, 472 or more	1, 272–1, 471	1, 100–1, 271	1, 099
55½		(3)	1, 306 or more	1, 129–1, 305	1, 128
56			1, 341 or more	1, 159–1, 340	1, 158
56½			1, 376 or more	1, 190–1, 375	1, 189
57			1, 413 or more	1, 221–1, 412	1, 220
57½			1, 450 or more	1, 253–1, 449	1, 252
58			1, 489 or more	1, 287–1, 488	1, 286
58½			(3)	1, 321 or more	1, 320
59				1. 356 or more	1, 355
59½				1, 392 or more	1, 391
60				1, 428 or more	1, 427

[1] Minimum weight. [2] Maximum weight. [3] Omission of weights explained in text.

Table 3 shows the slaughter grades of animals determined from the indicated heart girths and heights at withers. This table was calculated from table 1 by the use of heart-girth measurements instead of weights, and correcting for the effect of grade according to the method described by the writer.[10]

In the determination of grades, no series of weights and measurements is likely to be as satisfactory as competent, technically trained cattle graders, because measurements do not take into consideration the quality of the animal or the symmetrical balance that should exist in properly fattened animals. However, the proposed method will give a better determination of the slaughter grade of a steer than will an untrained grader provided the animal is a normally proportioned steer of domestic cattle (*Bos taurus*) and the measurements are accurately taken. This method does not apply in the grading of such domestic cattle as the Brahman and Africander, nor to animals carrying blood of other species, such as the yak or bison.

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[9] BLACK, W. H., KNAPP, BRADFORD, JR., and COOK, A. C. See footnote 4.

[10] KNAPP, BRADFORD, JR. A METHOD OF ESTIMATING THE WEIGHTS OF BEEF AND DUAL-PURPOSE CATTLE FROM HEART-GIRTH MEASUREMENTS. U. S. Bur. Anim. Indus. A. H. D. 24, 4 pp. 1937. [Mimeographed.]

TABLE 2.—*Comparison of judged and determined slaughter grades of 28 Hereford steers approximately 16 months of age*

Steer No.	Judged grades				Grades determined by measurements [1]		Agreement (+) or disagreement (−) between two methods of grading
	Obtained by—		Average				
	Grader 1	Grader 2	Score	Designation	Score	Designation	
1	85	85	85	Medium Choice	85	Medium Choice	+
2	82	78	80	Low Choice	82	Low Choice	+
3	78	75	77	High Good	78	High Good	+
4	85	82	84	Medium Choice	88	High Choice	−
5	78	78	78	High Good	78	High Good	+
6	82	82	82	Low Choice	82	Low Choice	+
7	82	82	82	do	78	High Good	−
8	82	82	82	do	82	Low Choice	+
9	82	82	82	do	82	do	+
10	75	75	75	Medium Good	75	Medium Good	+
11	78	75	77	High Good	78	High Good	+
12	82	78	80	Low Choice	82	Low Choice	+
13	78	75	77	High Good	78	High Good	+
14	78	72	75	Medium Good	75	Medium Good	+
15	75	72	74	do	75	do	+
16	78	75	77	High Good	75	do	−
17	78	78	78	do	82	Low Choice	−
18	82	82	82	Low Choice	85	Medium Choice	−
19	82	82	82	do	82	Low Choice	+
20	78	75	77	High Good	75	Medium Good	−
21	75	75	75	Medium Good	72	Low Good	−
22	75	75	75	do	75	Medium Good	+
23	78	78	78	High Good	75	do	−
24	72	72	72	Low Good	72	Low Good	+
25	78	78	78	High Good	82	Low Choice	−
26	85	85	85	Medium Choice	88	High Choice	−
27	82	78	80	Low Choice	82	Low Choice	+
28	78	78	78	High Good	78	High Good	+

[1] Determined from the following equation: Grade = −223.2839 − 3.5853 (H) + 157.9825 (log W). Figures converted to nearest third of grade.

TABLE 3.—*Slaughter-grade classification of steers on the basis of height at withers and heart girth*

Height of steers at withers (inches)	Heart girth of steers that grade—				
	Prime	Choice	Good	Medium	Plain
	Inches [1]	*Inches*	*Inches*	*Inches*	*Inches* [2]
38	64¾	60½–64½	56½–60¼	52¾–56¼	52½
38½	65½	61¼–65¼	57 –61	53¼–56¾	53
39	66	61¾–65¾	57¾–61½	54 –57½	53¾
39½	66½	62¼–66¼	58¼–62	54½–58	54¼
40	67¼	63 –67	59 –62¾	55 –58¾	54¾
40½	68	63¾–67¾	59½–63½	55½–59¼	55¼
41	68¾	64¼–68½	60 –64	56 –59¾	55¾
41½	69½	64¾–69¼	60½–64½	56¾–60½	56½
42	70	65½–69¾	61¼–65¼	57¼–61	57
42½	70¾	66¼–70½	62 –66	57¾–61¾	57½

[1] Minimum measurement.

[2] Maximum measurement.

TABLE 3.—*Slaughter-grade classification of steers on the basis of height at withers and heart girth*—Continued

Height of steers at withers (inches)	Heart girth of steers that grade—				
	Prime	Choice	Good	Medium	Plain
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
43	71½	66¾–71¼	62½–66½	58¼–62¼	58
43½	72¼	67½–72	63¼–67¼	59 –63	58¾
44	73	68¼–72¾	63¾–68	59½–63½	59¼
44½	73¾	69 –73½	64½–68¾	60¼–64¼	60
45	74½	69¾–74¼	65 –69½	60¾–64¾	60½
45½	75¼	70¼–75	65¾–70	61½–65½	61¼
46	76	71 –75¾	66½–70¾	62 –66¼	61¾
46½	76¾	71¾–76½	67 –71½	62¾–66¾	62½
47	77½	72½–77¼	67¾–72¼	63¼–67½	63
47½	78½	73¼–78¼	68½–73	64 –68¼	63¾
48	79¼	74 –79	69¼ 73¾	64½–69	64¼
48½	80	74¾–79¾	70 –74½	65¼–69¾	65
49	81	75½–80¾	70½–75¼	66 –70¼	65¾
49½	81¾	76¼–81½	71¼–76	66¾–71	66½
50	82½	77¼–82¼	72 –77	67¼–71¾	67
50½	83½	78 –83¼	72¾–77¾	68 –72½	67¾
51	84¼	78¾–84	73½–78½	68¾–73¼	68½
51½	85¼	79½–85	74¼–79¼	69½–74	69¼
52	86	80½–85¾	75 –80¼	70¼–74¾	70
52½	(3)	81½ or more	76 –81¼	71 –75¾	70¾
53		82¼ or more	76¾–82	71¾–76½	71½
53½		83 or more	77½–83¾	72½–77¼	72¼
54		84 or more	78½–83¾	73¼–78¼	73
54½		84¾ or more	79¼–84½	74 –79	73¾
55		85¾ or more	80 –85½	74¾–79¾	74½
55½		(3)	81 or more	75½–80¾	75¼
56			81¾ or more	76¼–81½	76
56½			82¾ or more	77¼–82½	77
57			83½ or more	78 –83¼	77¾
57½			84½ or more	78¾–84¼	78½
58			85½ or more	79¾–85¼	79½
58½			(3)	80½ or more	80¼
59				81½ or more	81¼
59½				82½ or more	82¼
60				83¼ or more	83

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[3] Omission of measurements explained in text.

SUMMARY

Data on 167 steers of Hereford, Shorthorn, Aberdeen Angus, and dairy breeding were used to develop a method of determining slaughter grade by the use of height at withers and weight or heart girth.

It was shown that a multiple curvilinear relationship exists between height at withers, weight, and slaughter grade. The equation derived from the data was

$$\text{Grade} = -223.2839 - 3.5853\ (H) + 157.9825\ (\log W),$$

in which grade is the slaughter grade in percent, (H) is the height at withers in inches, and $(\log W)$ is the log of live weight in pounds.

A table is presented showing the slaughter-grade classification on the basis of height at withers and weight. A table also is included showing the grades obtained from measurements as compared with the grades judged by two technically trained graders. The greatest deviation between the two methods was one-half of a grade.

A third table is presented showing slaughter-grade classification on the basis of height at withers and heart girth. This method may be used when scales are not available.

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